PENNICHUCK BROOK WATERSHED BUILD-OUT ANALYSIS

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Prepared by the

Nashua Regional Planning Commission

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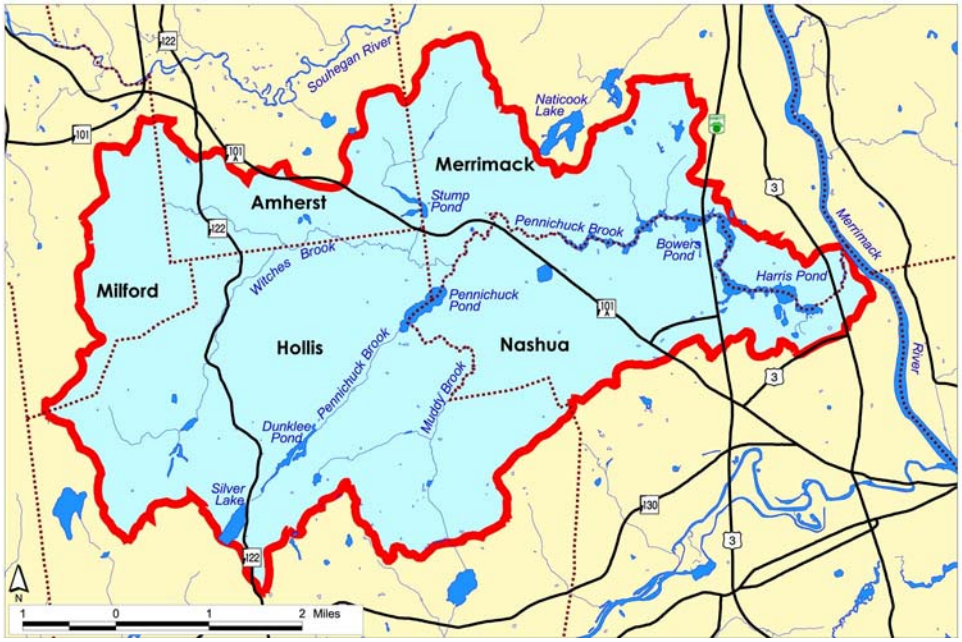
INTRODUCTION

The Pennichuck Brook watershed (Figure 1) includes approximately 17,700 acres within the communities of Amherst, Hollis, Merrimack, Milford and Nashua and is the primary drinking water supply for the City of Nashua and several of other communities. Several areas of the watershed are rapidly developing, which, in turn, is impacting the watershed. The Pennichuck Watershed Council was established to protect the water supply from the impacts of this development in the watershed. In 2003, the Nashua Regional Planning Commission obtained grant funds under the Regional Environmental Planning Program to assist in developing a better understanding of the current health of the watershed and work with the surrounding communities to develop a comprehensive approach toward watershed protection.

The goal of this analysis was to devise a series of maps that can be used to protect the ecological integrity of the Pennichuck Brook watershed by forecasting how the impacts of future development could affect drinking water quality. The project was developed using Geographic Information System (GIS) technology. The project includes four tasks, as follows:

- Task 1. Existing Conditions Analysis
- Task 2. Riparian Buffer Analysis
- Task 3. Impervious Surface Analysis
- Task 4. Buildout Analysis

Figure 1: Pennichuck Brook Watershed Location



Source: NRPC GIS, 2003

TASK 1. EXISTING CONDITIONS ANALYSIS

Understanding the present conditions in a watershed is essential in order to estimate potential future changes. In the first task, existing GIS data for the watershed was collected to develop a base map of the watershed. Map 1 provides a snapshot of the existing conditions in the watershed. The various features on Map 1 include community and watershed boundaries, parcels, roads and waterbodies. Note: In order to be consistent, the information used to develop Map 1 and subsequent maps included the existing conditions in the watershed as of February 2003. The GIS data sources that were used to develop the base map are in Appendix A.

TASK 2. RIPARIAN BUFFER ANALYSIS

In the second task, existing and proposed riparian buffers in the watershed were identified for the purpose of understanding the existing level of protection as well as what is potentially available for future protection in the watershed. Riparian buffers are strips of vegetation along the banks of rivers and streams that filter polluted runoff and provide a transition zone between water and human land use.[1] They are an effective and cost-efficient best management practice that can be used to maintain or enhance water quality, prevent flooding, and provide wildlife habitat.

State and municipal land use regulations and restrictive covenants effective within the Pennichuck Brook watershed have established riparian buffers within a defined distance from the shoreline. These regulations provide a variety of protection to the surface waters in the watershed. For example, the City of Nashua established a 75-foot no-disturbance buffer around all prime wetlands and Pennichuck Pond and its tributaries. The Town of Hollis, however, designated a 100-foot restricted buffer around all wetlands and hydric soils in addition to Pennichuck Pond and its tributaries. Table 1 summarizes the various buffers applicable to the watershed. Map 2 illustrates these established buffers for the entire watershed.

As shown in Table 1, the established riparian buffers provide some areas of the watershed more protection than others. For example, a restrictive covenant established a 500-foot buffer around the Supply Pond and 300-foot buffer around the remaining ponds. In order to protect water quality in the watershed, however, the *Pennichuck Water Works Watershed Management Plan* recommends "to use a 400-foot buffer around all the chain ponds and a 200-foot buffer from the Ordinary High Water Mark around the tributaries and wetlands that are directly adjacent to the chain ponds."[2] The Pennichuck Brook Watershed Council suggested that the 400-foot buffer be extended to include the chain ponds and all of the tributaries in the watershed (see Map 3).

Once the suggested 400-foot buffer was mapped, the watershed was analyzed to determine if there were areas that could be further protected through acquisition of land. All of the undeveloped and unprotected parcels in the watershed were identified. Any of these parcels that are adjacent to the suggested 400-foot buffer (shown in pink on Map 4) were labeled as potentially available for acquisition.

[1] Connecticut River Joint Commissions, *Introduction to Riparian Buffers*, September 2000.
[2] Comprehensive Environmental, Inc., *Pennichuck Water Works Watershed Management Plan*, August 1998.

Table 1: Established Riparian Buffers in the Pennichuck Brook Watershed

Municipality or Entity	Pennichuck Ponds	Pennichuck Brook and Tributaries	Wetlands Adjacent to Pennichuck Ponds and Tributaries
Lands now or formerly owned by **Pennichuck** (Restrictive covenants)	±50 ft "Critical Area" includes wetlands, floodplains, shoreline, and adjacent steep slopes Natural state except road and utility crossings		
	500 ft buffer for Supply Pond critical area; 300 ft buffer for other ponds' critical areas	300 ft buffer for tributaries' critical areas	100 ft buffer for other wetlands
	Buffer areas natural state except limited clearing		
Nashua	225 ft undisturbed except for veg. swales ("Conservation zone"); 300 ft No fertilizers or pesticides	75 ft undisturbed except for veg. swales ("Conservation zone"); 150 ft No fertilizers or pesticides; stormwater treatment and infiltration requirement	
Hollis	100 ft no construction activity (or 14 other prohibited uses) for wetlands and hydric soils (exemptions for agriculture and forestry); most (all?) of Pennichuck Pond is bordered by wetlands		
Merrimack	250 ft Protected Shoreland (25 ft No fertilizer or clearing; 40 ft no building; 50 ft Primary Building Setback; 150 ft Natural Woodland Buffer; soils-based lot size and septic setbacks; no salt piles, waste facilities, junk yards); most is former Pennichuck land		
Amherst	Not in Amherst	100 ft naturally vegetated buffer for Public Water Protection Wetlands (includes certain wetlands in watershed); 25 ft for other wetlands: no filling or alteration of contours, except as determined by Planning Board (may require a mitigation plan), as for road/driveway crossings, forestry and agriculture acc to BMPs	
Milford	Not in Milford	50 ft no disturbance; 100 ft setback for leach fields; all zoned residential	25 ft no disturbance
Entire watershed (NH **DES rule**)	75 ft No privies, structures housing animals, septic systems, solid waste, wastewater		

Source: New Hampshire Department of Environmental Services, 2003

The following steps were taken to analyze the existing and proposed riparian buffers in the watershed:

1. **Assign a generalized land use category to each parcel.** Each parcel in the watershed was assigned a generalized land use category: agricultural, conservation, developed (which includes roads), water (hydric), and vacant. Tables 2A and 2B present the acreage and percentage of these land uses within each community and subwatershed in the watershed. This allowed for the selection of parcels by land use.

Table 2A: Generalized Land Uses by Municipality

Municipality	Agriculture		Conservation		Developed		Water		Vacant		**Total Area in Watershed (acres)**
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Amherst	0	0%	3	0%	866	48%	48	3%	898	49%	1,814
Hollis	1,192	16%	873	11%	2,711	36%	481	6%	2,362	31%	7,619
Merrimack		0%	184	5%	1,763	51%	201	6%	1,278	37%	3,427
Milford	11	1%	93	7%	338	26%		0%	870	66%	1,312
Nashua	11	0%	449	13%	2,280	65%	287	8%	493	14%	3,520
Total	1,214	7%	1,602	9%	7,959	45%	1,018	6%	5,901	33%	17,694

Source: NRPC GIS, 2003.

Table 2B: Generalized Land Uses by Subwatershed

Subwatershed	Agriculture		Conservation		Developed		Water		Vacant		**Total Area in Watershed (acres)**
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Muddy Brook	617	22%	414	15%	734	26%	212	7%	857	30%	2,834
Pennichuck Brook (N)	17	0%	429	7%	3,255	57%	478	8%	1,551	27%	5,730
Pennichuck Brook (S)	298	19%	286	18%	443	28%	89	6%	439	28%	1,554
Witches Brook (N)	68	1%	53	1%	2,528	53%	223	5%	1,882	40%	4,755
Witches Brook (S)	215	8%	420	15%	998	35%	15	1%	1,173	42%	2,821
Total	1,214	7%	1,602	9%	7,959	45%	1,018	6%	5,901	33%	17,694

Source: NRPC GIS, 2003

2. **Research and map established riparian buffers.** The established riparian buffer dimensions differed by municipality and land use as shown in Table 1. The buffer criteria were analyzed and applied to all parcels based on the land uses identified in the previous step. All applicable buffers, for each land use, were then merged into one GIS coverage to create a map of the established riparian buffers in the watershed (see Map 2).

3. **Map the suggested 400-foot riparian buffer.** The suggested 400-foot buffer was placed around every chain pond and tributary in the watershed (see Map 3). Tables 3A and 3B summarize the area of the suggested 400-foot buffer in each municipality and subwatershed, respectively.

4.

Table 3A: Area of Suggested 400-foot Buffer by Municipality

Municipality	Suggested 400-foot Buffer (acres)	Area of Municipality in Watershed (acres)
Amherst	360	1,813
Hollis	1,371	7,629
Merrimack	602	3,419
Milford	9	1,309
Nashua	607	3,524
Total Acres	2,949	17,694

Source: NRPC GIS, 2003

Table 3B: Area of Suggested 400-foot Buffer by Subwatershed

Subwatershed	Suggested 400-foot Buffer (acres)	Area of Subwatershed in Watershed (acres)
Muddy Brook	563	2,834
Pennichuck Brook (N)	981	5,730
Pennichuck Brook (S)	315	1,554
Witches Brook (N)	759	4,755
Witches Brook (S)	331	2,821
Total	2,949	17,694

Source: NRPC GIS, 2003

5. **Remove conservation and developed parcels.** Parcels that were identified as conservation or developed land were removed from consideration for potential acquisition.

6. **Analyze remaining land for potential acquisition.** Map 4 was analyzed to identify parcels that were undeveloped, unprotected and adjacent to the suggested 400-foot buffer. These parcels are considered potentially available for acquisition or other protective measures. Tables 4A and 4B analyze the area of the suggested 400-foot buffer that is adjacent to undeveloped, unprotected land. Tables 5A and 5B analyze the total area of the undeveloped, unprotected land that is adjacent to the suggested 400-foot buffer.

7.

The area of the suggested 400-foot buffer that is adjacent to undeveloped, unprotected land in the municipalities and the subwatersheds is summarized in Tables 4A and 4B. A total of 564 acres of the suggested 400-foot buffer are adjacent to vacant lands with the majority located in the Town of Hollis, with a total of 211 acres. Witches Brook North, which is located in the Towns of Milford, Amherst Merrimack and Hollis, contains the largest area of the suggested 400-foot buffer with 195 acres. Map 4 displays the areas where the suggested 400-foot buffer intersects these vacant parcels.

Tables 5A and 5B summarize the total area of the undeveloped, unprotected parcels that are adjacent to the suggested 400-foot buffer. 3,380 acres of vacant land in the watershed is adjacent to the suggested

400-foot buffer, with a majority of the parcels found in the Pennichuck Brook North subwatershed which is located in the City of Nashua and the Town of Merrimack. As indicated on Map 4, a large portion of these vacant parcels are located in the Town of Merrimack, north of the ponds.

Table 4A: Area of Suggested 400-foot Buffer Adjacent to Undeveloped, Unprotected Parcels by Municipality

Municipality	Area of Suggested 400' buffer Adjacent to Undeveloped, Unprotected Parcels (acres)	Total Area of Municipality in Watershed (acres)
Amherst	**159**	**1,813**
Hollis	**211**	**7,629**
Merrimack	**98**	**3,419**
Milford	**7**	**1,309**
Nashua	**88**	**3,524**
Total	**564**	**17,694**

Source: NRPC GIS, 2003

Table 4B: Area of Suggested 400-foot Buffer Adjacent to Undeveloped, Unprotected Parcels by Subwatershed

Subwatershed	Area of Suggested 400' buffer Adjacent to Undeveloped, Unprotected Parcels (acres)	Total Area of Subwatershed in Watershed (acres)
Muddy Brook	82	2,834
Pennichuck Brook (N)	161	5,730
Pennichuck Brook (S)	35	1,554
Witches Brook (N)	195	4,755
Witches Brook (S)	90	2,821
Total	564	17,694

Source: NRPC GIS, 2003

Tables 5A: Area of Undeveloped, Unprotected Parcels Adjacent to Suggested 400-foot Buffer by Municipality

Municipality	Total Area of the Parcels Adjacent to Suggested 400′ Buffer (acres)	Total Area of Municipality in Watershed (acres)
Amherst	555	1,813
Hollis	1,605	7,629
Merrimack	813	3,419
Milford	41	1,309
Nashua	365	3,524
Total	3,380	17,694

Source: NRPC GIS, 2003

Table 5B: Area of Undeveloped, Unprotected Parcels Adjacent to Suggested 400-foot Buffer by Subwatershed

Subwatershed	Total Area of the Parcels Adjacent to Suggested 400' Buffer (acres)	Total Area of Subwatershed (acres)
Muddy Brook	818	2,834
Pennichuck Brook (N)	1,146	5,730
Pennichuck Brook (S)	237	1,554
Witches Brook (N)	842	4,755
Witches Brook (S)	338	2,821
Total	3,380	17,694

Source: NRPC GIS, 2003

TASK 3. IMPERVIOUS SURFACE ANALYSIS

In the third task, the amount of impervious surface in the watershed was identified. Impervious surfaces such as roofs, roads, parking lots and driveways increase the rate by which pollutants accumulate and run off into water bodies during storm events. This runoff can potentially degrade water quality. The rate and flow of runoff is exacerbated with increased imperviousness and intensity of land use. A study by the Center for Watershed Protection suggests that a watershed may be impacted when there is as little as 11% impervious cover (see Figure 22). At this percentage, streams may show signs of degradation due to watershed urbanization. The definitions of the three categories used to gauge the health of a watershed based on impervious cover is in Appendix B.

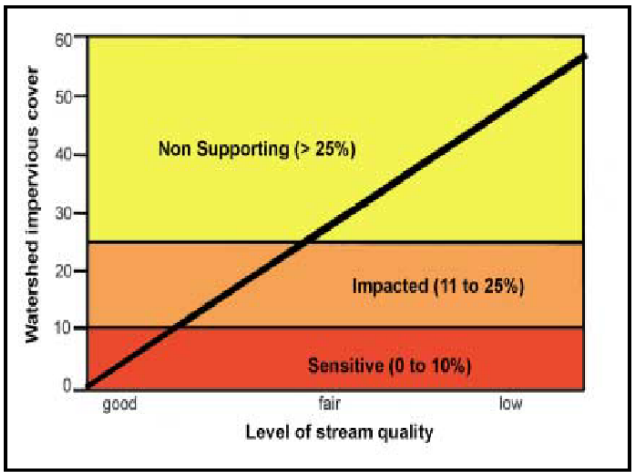


Figure 2: Impervious Cover Model
Source: Center for Watershed Protection, www.cwp.org

The Center for Watershed Protection developed a methodology which uses multipliers to estimate the amount of impervious area for various land uses in a watershed (see Table 6). Each multiplier indicates the "typical" amount of impervious surface occupied by each land use. Using these multipliers, the amount of impervious surface in the Pennichuck Brook watershed was calculated in two ways: 1) based on actual data collected in the field along the NH Route 101A corridor; and 2) based on estimates for existing land uses in the remainder of the watershed. These two areas are depicted in Figure 3.

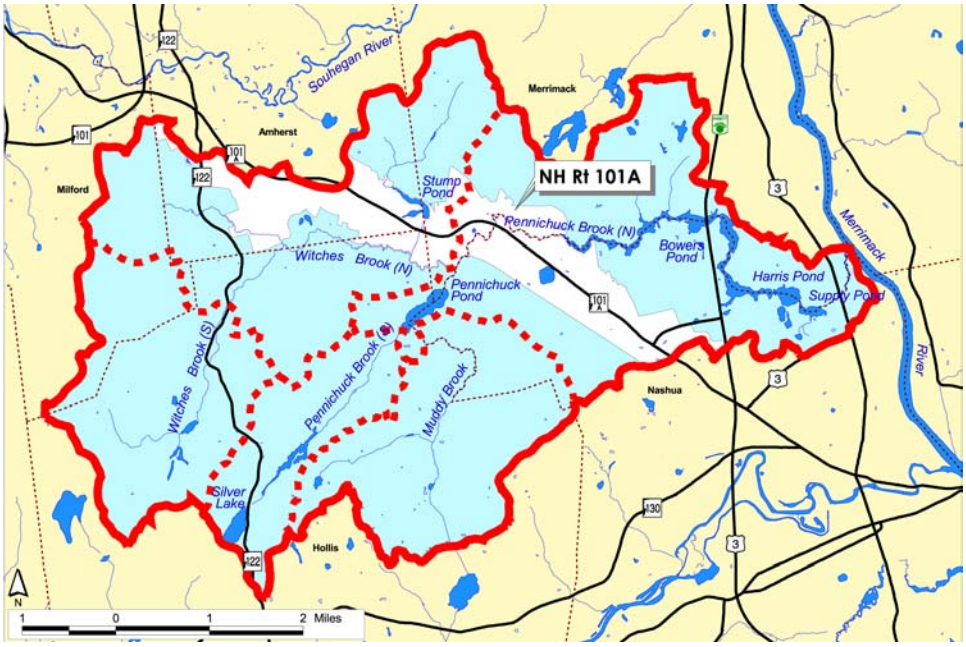
Table 6: Impervious Area Coefficient by Land Use Category

Land Use Category	Impervious Area Coefficient (% of Total Area)
Vacant	0.0%
Conservation Land	0.0%
Agriculture	1.9%
Open Urban Land	8.6%
2 Acre Lot Residential	10.6%
1 Acre Lot Residential	14.3%
1/2 Acre Lot Residential	21.2%
1/8 Acre Lot Residential	32.6%
Townhome Residential	40.9%
Multifamily Residential	44.4%
Institutional	34.4%
Industrial	53.4%
Commercial	72.2%
Road	100%
Water	0.0%

Source: Center for Watershed Protection, www.cwp.org

In 2002, NRPC completed the *NH Route 101A Corridor Study and Master Plan*. The study area, depicted in Figure 3, contains approximately 2,053 acres of urbanized area in the Pennichuck Brook watershed. The study includes precise data collected for each parcel located within 1,500 feet of the centerline of the NH Route 101A corridor. The accuracy of the data enabled the GIS staff to calculate the actual impervious surface cover for the corridor. Detailed parcel data does not exist for the area outside of the corridor, however, so it was estimated based on existing land uses.

Figure 3: NH Route 101A Corridor Area



Source: NRPC GIS, 2003

Using the coefficients for various land uses presented in Table 6, the data was calculated separately for the NH Route 101A corridor (see Tables 7A and 7B) and the remainder of the watershed (see Appendix C and D). The two data sources were then combined to create a total impervious surface percentage for the watershed (see Map 5). The combined results are presented in Tables 8A and 8B.

Task 3 includes the following steps:

1. **Calculate impervious surface in the NH Route 101A corridor study area.** Using the detailed information collected for the parcels along the NH Route 101A corridor, the area of impervious surface was calculated for the corridor. Tables 7A and 7B present the area of impervious surface by subwatershed and municipality for the portion of NH Route 101A corridor within the watershed.

Table 7A: Area of Existing Impervious Surface along the NH Route 101A Corridor by Municipality

Municipality	Total Area in Corridor (acres)	Area of Existing Impervious Surface (acres)	% Existing Impervious Surface
Amherst	741	73	10%
Hollis	88	0	0%
Merrimack	400	93	23%
Nashua	824	305	37%
Total	2,053	472	23%

Source: NRPC GIS, 2003

Table 7B: Area of Impervious Surface along the NH Route 101A Corridor by Subwatershed

Subwatershed	Total Area in Corridor (acres)	Area of Existing Impervious Surface (acres)	% Existing Impervious Surface
Pennichuck Brook (N)	1,066	355	33%
Witches Brook (N)	987	116	12%
Total	2,053	472	23%

Source: NRPC GIS, 2003

2. **Refine land use categories for the remainder of the watershed.** The purpose of refining the land use categories was to identify the specific use on each parcel in order to utilize the methodology created by the Center for Watershed Protection. The land use categories identified in Table 6 were then assigned to each parcel.

3. **Calculate the impervious surface percentage for the remainder of the watershed.** Using the multipliers developed by the Center for Watershed Protection in Table 6, the area of impervious surface on each parcel in the remainder of the watershed was identified. The results were calculated by subwatershed and by municipality (see Appendix C and D).

4. **Calculate total impervious surface for the entire watershed.** The area of impervious surface calculated for the NH Route 101A corridor and for the remainder of the watershed were combined to identify the total area of existing impervious surface for the entire watershed. Tables 8A and 8B present the total area of impervious surface by subwatershed and municipality. The area of impervious surface is illustrated on Map 5.

Table 8A: Area of Impervious Surface by Municipality

Municipality	Total Area in Watershed (acres)	Area of Existing Impervious Surface (acres)	% Existing Impervious Surface
Amherst	1,813	274	15%
Hollis	7,629	524	7%
Merrimack	3,419	585	17%
Milford	1,309	57	4%
Nashua	3,524	984	28%
Total	17,694	2,423	14%

Source: NRPC GIS, 2003

Table 8B: Area of Impervious Surface by Subwatershed

Subwatershed	Total Area in Watershed (acres)	Area of Existing Impervious Surface (acres)	% Existing Impervious Surface
Muddy Brook	2,834	160	6%
Pennichuck Brook (N)	5,730	1,381	24%
Pennichuck Brook (S)	1,554	96	6%
Witches Brook (N)	4,755	615	13%
Witches Brook (S)	2,821	171	6%
Total	17,694	2,423	14%

Source: NRPC GIS, 2003

The results of this analysis are summarized by subwatershed and municipality in Tables 8A and 8B. Table 8A indicates that approximately 2,423 acres, or 14%, of the watershed, is currently impervious. Map 5 indicates that the more impervious surfaces are concentrated along the NH Route 101A corridor and in the City of Nashua in general.

As shown in Appendices C and D, several land uses in the watershed are contributing greatly to the existing area of impervious surface: buildings, commercial and industrial uses, multifamily and townhomes, and roads. The two subwatersheds that are affected the most by these land uses are Pennichuck Brook North and Witches Brook North, with 24% and 13% of imperious surface respectively (see Appendix C). According to the Center for Watershed Protection's impervious cover model (see Figure 3 and Appendix B), watersheds with 11-25% imperviousness can be considered impacted and may "show clear signs of degradation." The model also indicates that watersheds that are greater than 25% impervious may be considered non-supporting. For example, the existing area of impervious surface in the Pennichuck Brook North subwatershed is 1,381 acres. If approximately 52 additional acres of impervious surface are developed then the subwatershed may be placed in the non-supporting category because it will have reached an impervious surface cover of 25%.

TASK 4. BUILD-OUT ANALYSIS

A build-out analysis of the watershed was completed in Task 4. A build-out analysis is a theoretical assessment of the quantity of new development that could be constructed based on a community's existing land use regulations and physical development constraints. The results of a build-out analysis can be used to estimate the future area of impervious surface in a watershed. Map 6 illustrates the amount of potential new development in the Pennichuck Brook watershed.

Task 4 includes the following steps:

1. **Identify undeveloped land.** Parcels that are undeveloped were identified and verified by examining aerial photography and field review, as required.

2. **Remove undevelopable land.** The portions of parcels constrained by wetlands, steep slopes (>25%), floodplains, agricultural soils and established buffers (see Table 1) were classified as un-buildable and subtracted from the area of undeveloped land.

3. **Remove small parcels.** Lots less than or equal to the minimum lot size requirement designated by each community's zoning ordinance were considered undevelopable and subtracted from the total area of undeveloped land.

4. **Remove 5% for subdivision regulations.** Five percent (5%) of the remaining area of undeveloped land was subtracted to account for design issues and required rights-of-ways in a subdivision. The result is the "net developable area."

5. **Divide by minimum lot size.** The net developable area was divided by the minimum lot size designated by each community's zoning ordinance. The result is the maximum build-out potential by number of lots. This is expressed at the municipal and subwatershed levels, as indicated in Appendices F and G.

6. **Calculate potential future area of impervious surface.** Each potential new parcel was multiplied by the Center for Watershed Protection's impervious surface coefficient for the associated land use designation/zoning category. The total potential area of impervious surface was then added to the existing area of impervious surface to yield the total potential future area of impervious surface at build-out. The results are summarized in Tables 9A and 9B and illustrated on Map 6.

The results of the build-out analysis, summarized in Tables 9A and 9B, indicate that an additional 3,337 acres of impervious surface could be developed in the watershed. This will increase the impervious surface coverage in the watershed from 14% to 32% which, according to the Center for Watershed Protection impervious cover model, is well within the non-supporting category.

Table 9B shows that the additional impervious surface could potentially place two of the five subwatersheds in the non-supporting category – Pennichuck Brook North and Witches Brook North. Over half (53%) of the Pennichuck Brook North watershed is estimated to be developed by impervious surfaces at build-out with the majority of the new development located north of the ponds in the Town of Merrimack. In the Witches Brook North subwatershed, just over one-third (32%) is estimated to be developed with impervious surfaces, with the bulk of the development located in the Towns of Amherst and Milford.

As shown on Map 6, the majority of the development in the remainder of the watershed is estimated to be in existing rural areas such as the eastern section of the Town of Hollis, most of the

section of the Town of Milford that is in the watershed, and the area south of NH Route 101A in the Town of Amherst.

Table 9A: Total Area of Potential Future Impervious Surface by Municipality

Municipality	Total Area in Watershed (acres)	Existing Area of Impervious Surface (acres)	Potential Area of Additional Impervious Surface (acres)	Total Area of Future Impervious Surface (acres)	Existing % Impervious Surface	Potential Future % Impervious Surface
Amherst	1,813	274	487	761	15%	42%
Hollis	7,629	524	808	1,332	7%	17%
Merrimack	3,419	585	776	1,361	17%	40%
Milford	1,309	57	153	209	4%	16%
Nashua	3,524	984	1,113	2,097	28%	59%
Total	17,694	2,423	3,337	5,760	14%	32%

Source: NRPC GIS, 2003

Table 9B: Total Area of Potential Future Impervious Surface by Subwatershed

Subwatershed	Total Area in Watershed (acres)	Existing Area of Impervious Surface (acres)	Potential Area of Additional Impervious Surface (acres)	Total Area of Future Impervious Surface (acres)	Existing % Impervious Surface	Potential Future % Impervious Surface
Muddy Brook	2,834	160	305	465	6%	16%
Pennichuck Brook (N)	5,730	1,381	1,648	3,028	24%	53%
Pennichuck Brook (S)	1,554	96	155	250	6%	16%
Witches Brook (N)	4,755	615	930	1,545	13%	32%
Witches Brook (S)	2,821	171	300	472	6%	17%
Total	17,694	2,423	3,337	5,760	14%	32%

Source: NRPC GIS, 2003

CONCLUSION

The figures and maps presented in this report are based on an analysis of statistical data, local zoning ordinances and private covenants. These data sources were used to develop an estimate of the potential area of impervious surface that could be developed within the Pennichuck Brook watershed. This analysis can be used by municipalities to evaluate the impacts of local zoning, review proposed development, and suggest transportation improvements in the watershed. The figures provided in this analysis can be used as indicators of the current health and state of the watershed which can, in turn, be used to cooperatively develop a more comprehensive approach towards watershed protection. The analysis can be used as a local and regional guide to gauge the health of the subwatersheds within each community and mitigate development impacts to protect the health and ecological integrity of the Pennichuck Brook Watershed.

APPENDIX A

GIS Data Layers for Base Mapping

Data Layer	Source	Description
Community Boundaries	GRANIT	Data was distributed by GRANIT
Parcels	NRPC/ Local assessing records and maps	Parcels were assigned a unique identification value indicating the municipality, subwatershed and map-lot-sublot descriptive values.
Roads	NH DOT	Updated by NRPC field review, 2002
Hydrography	USGS/GRANIT	Data was distributed by GRANIT
Conservation Lands	SPNHF/The Nature Consevancy/Sweetwater Trust/GRANIT/NRPC	Based on a regional updata to the State of NH Conservation Lands Inventory, 2002

Note: NH DOT = NH Department of Transportation; GRANIT = Geographically Referenced Analysis and Information Transfer System; SPNHF = Society for the Protection of New Hampshire's Forests.

APPENDIX B

Definitions of the Impervious Surface Model Categories

Sensitive Stream - Subwatershed typically has impervious cover of 0-10%. Streams are of high quality, and are typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects. Since impervious cover is so low, they do not experience frequent flooding and other hydrological changes that accompany urbanization.

Impacted Stream - Subwatershed typically has impervious cover ranging from 11-25%, and shows clear signs of degradation due to watershed urbanization. Greater storm flows begin to alter the stream geometry. Both erosion and channel widening are evident in alluvial streams. Stream banks become unstable, and physical habitat in the stream declines noticeably. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with the most sensitive fish and aquatic insects disappearing from the stream.

Non-Supporting Stream - Subwatershed impervious cover exceeds 25%. Streams in this category essentially become a conduit for conveying stormwater flows, and can no longer support a diverse stream community. The stream channel is often highly unstable, and stream reaches can experience severe widening, down-cutting and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated, and the stream substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water-contact recreation is no longer possible due to the presence of high bacterial levels. The biological quality of non-supporting streams is generally considered poor, and is dominated by pollution tolerant insects and fish.

APPENDIX C

Existing Area of Impervious Surface by Land Use by Subwatershed *

Land Use	Muddy Brook		Pennichuck Brook (N)		Pennichuck Brook (S)		Witches Brook (N)		Witches Brook (S)		Total Area of Existing Imperv. Surface (acres)	Total Area of Land Use (acres)	**Total % Imperv. Surface in Watershed**
	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area			
1 Acre Res.	0	0	25	177	0	0	1	6	0	0	26	183	14%
1/2 Acre Res.	3	14	44	206	0	0	0	0	0	0	47	221	21%
1/8 Acre Res.	0	0	13	48	0	0	0	0	0	0	13	48	27%
2 Acre Res.	69	649	52	488	39	368	169	1,596	99	930	427	4,031	11%
3 Acre Res.	0	0	0	0	0	0	6	58	0	0	6	58	11%
Agriculture	12	638	0	17	6	298	1	72	4	215	24	1,239	2%
Building	0	0	18	18	0	0	0	0	0	0	18	18	100%
Commercial	0	0	36	49	0	0	6	8	0	0	41	57	72%
Conservation	0	508	0	552	0	296	0	94	0	425	0	1,875	0%
Industrial	0	0	131	245	0	0	51	95	0	0	182	340	53%
Institution	7	21	88	255	0	0	0	0	0	0	95	276	34%
Multifamily	0	0	47	105	0	0	0	0	0	0	47	105	44%
Open Urban Land	3	31	17	188	2	23	7	80	0	0	29	322	9%
Townhome	0	0	58	143	0	0	0	0	0	0	58	143	41%
Road	66	66	496	496	49	49	258	258	69	69	938	938	100%
Vacant	0	896	0	1,405	0	455	0	1,501	0	1,182	0	5,440	0%
Water	0	11	0	270	0	65	0	0	0	0	0	345	0%
Total Area (acres)	160	2,834	1,026	4,664	96	1,554	499	3,767	171	2,821	1,952	15,640	12%
Total Percent Impervious	6%		22%		6%		13%		6%		12%		

Source: NRPC GIS, 2003

***Note: Table does not include NH Route 101A**

APPENDIX D

Existing Area of Impervious Surface by Land Use by Municipalities *

Land Use	Amherst		Hollis		Merrimack		Milford		Nashua		Total Area of Existing Imperv. Surface (acres)	Total Area of Land Use (acres)	**Total % Imperv. Surface in Watershed**
	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area	Imperv. Area	Total Area			
1 Acre Res.	0	0	0	0	0	0	1	6	25	177	26	183	14%
1/2 Acre Res.	0	0	0	0	0	0	0	0	47	221	47	221	21%
1/8 Acre Res.	0	0	0	0	0	0	0	0	13	48	13	48	27%
2 Acre Res.	36	341	256	2,411	103	969	33	310	0	0	427	4,031	11%
3 Acre Res.	0	0	0	0	6	58	0	0	0	0	6	58	11%
Agriculture	0	0	23	1,218	0	0	0	11	0	11	24	1,239	2%
Building	0	0	0	0	8	8	0	0	9	9	18	18	100%
Commercial	0	0	5	7	1	1	0	0	36	49	41	57	72%
Conservation	0	4	0	1,001	0	215	0	93	0	561	0	1,875	0%
Industrial	51	95	0	0	61	114	0	0	70	132	182	340	53%
Institution	0	0	0	0	0	0	0	0	95	276	95	276	34%
Multifamily	0	0	0	0	47	105	0	0	0	0	47	105	44%
Open Urban Land	0	0	10	115	2	26	0	0	17	180	29	322	9%
Townhome	0	0	0	0	0	0	0	0	58	143	58	143	41%
Road	114	114	231	231	264	264	23	23	307	307	938	938	100%
Vacant	0	517	0	2,460	0	1,157	0	897	0	439	0	5,440	0%
Water	0	0	0	98	0	100	0	0	0	147	0	345	0%
Total Area (acres)	201	1,072	524	7,541	492	3,018	57	1,309	678	2,700	1,952	15,640	12%
Total Percent Impervious	19%		7%		16%		4%		25%		12%		

Source: NRPC GIS, 2003

***Note: Table does not include NH Route 101A**

APPENDIX E

Constraints to Development GIS Layers

Data Layer	Description
Agricultural Soils	Data from USDA/NRCS andFIRM which includes soil types and attributes
Floodplains	100 and 500-year floodplains as depicted by FIRM
Steep Slopes (>25%)	Data from USDA/NRCS includes soil types and attributes
Wetlands	Data from GRANIT based on USGS Digital Line Graph
Existing Buffer Criteria	Includes buffer distances around water designated by NH DES, Pennichuck Corporation and Zoning Ordinances from Amherst, Hollis, Merrimack, Milford and Nashua

Note: USDA SCS = US Dept. of Agriculture, Soil Conservation Service; NRCS = Natural Resource Conservation Service; FIRM = Flood Insurance Rate Map; NH DES = New Hampshire Dept. of Environmental Services

APPENDIX F

Build-out Potential by Municipality

Municipality	Area in Watershed		Area of Potentially Developable Land			Area of Undevelopable Land			Potential Number of New Lots*		
	% of Watershed	Acres	% of Community	% of Watershed	Acres	% of Community	% of Watershed	Acres	% of Community	% of Watershed	Acres
Amherst	10%	1,813	36%	4%	659	14%	1%	262	23%	2%	421
Hollis	43%	7,629	24%	11%	1,866	24%	11%	1,865	11%	5%	811
Merrimack	19%	3,421	16%	3%	554	22%	4%	758	36%	7%	1,227
Milford	7%	1,308	44%	3%	572	23%	2%	306	35%	3%	454
Nashua	20%	3,522	10%	2%	352	5%	1%	161	14%	3%	499
Totals	**100%**	**17,694**			**4,003**			**3,351**			**3,412**

Source: NRPC GIS, 2003

*** Number of new lots was determined by dividing the minimum lot size designated by each community's zoning ordinance, yielding the maximum build-out potential by number of lots.**

APPENDIX G

Build-out Potential by Subwatershed

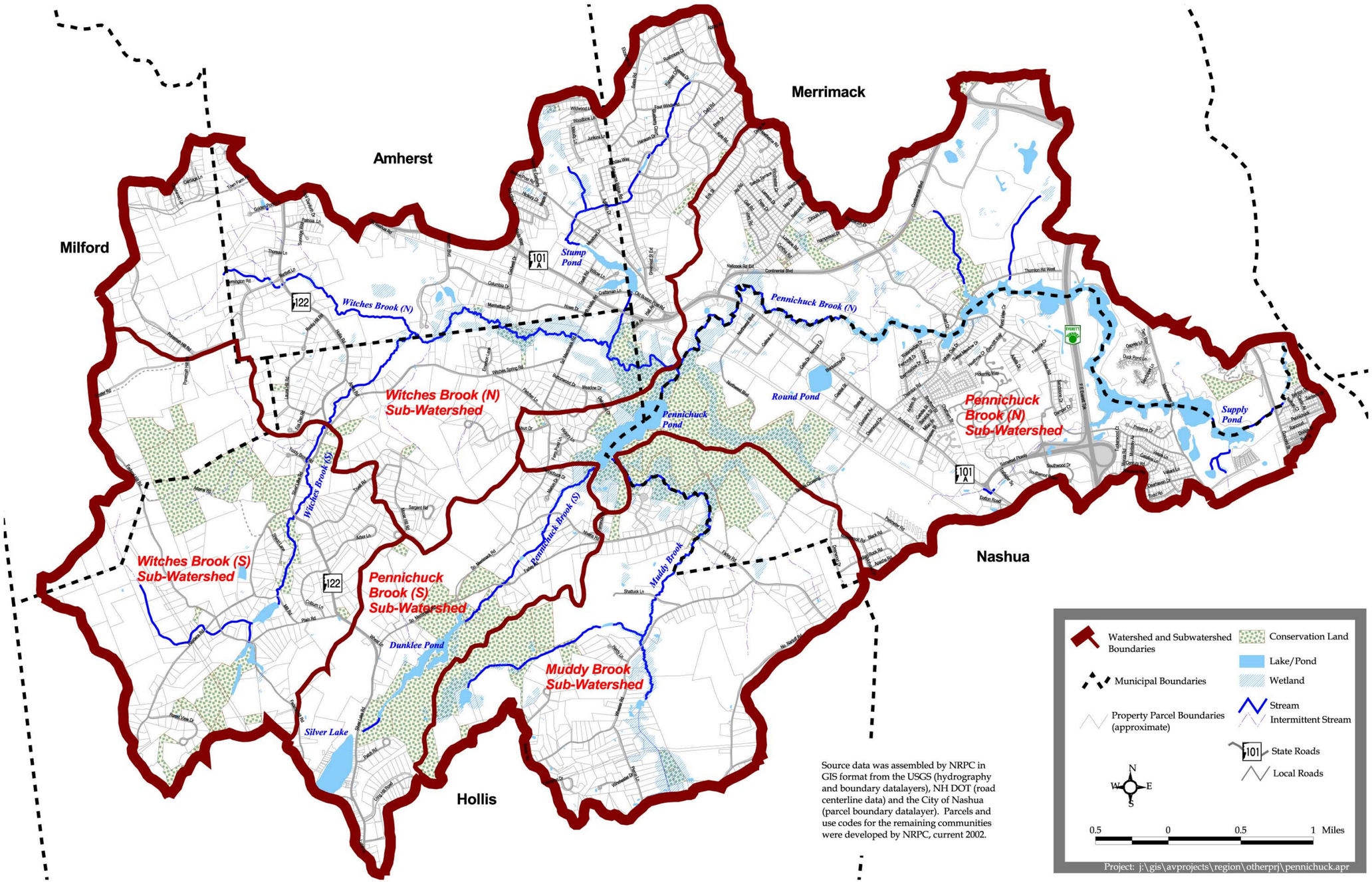
Subwatershed	Area in Watershed		Area of Potentially Developable Land			Area of Undevelopable Land			Potential Number of New Lots*		
	% of Watershed	Acres	% of Community	% of Watershed	Acres	% of Community	% of Watershed	Acres	% of Community	% of Watershed	Acres
Muddy Brook	16%	2,834	26%	4%	749	28%	4%	785	18%	3%	501
Pennichuck Brook (N)	32%	5,730	13%	4%	749	15%	5%	867	26%	8%	1,489
Pennichuck Brook (S)	9%	1,554	25%	2%	391	23%	2%	363	11%	1%	166
Witches Brook (N)	27%	4,754	27%	7%	1,307	16%	4%	746	16%	4%	774
Witches Brook (S)	16%	2,821	29%	5%	807	21%	3%	590	17%	3%	482
Totals	**100%**	**17,694**			**4,003**			**3,351**			**3,412**

Source: NRPC GIS, 2003

*** Number of new lots was determined by dividing the minimum lot size designated by each community's zoning ordinance, yielding the maximum build-out potential by number of lots.**

#530E-10

Map 1: Existing Conditions



Source data was assembled by NRPC in GIS format from the USGS (hydrography and boundary datalayers), NH DOT (road centerline data) and the City of Nashua (parcel boundary datalayer). Parcels and use codes for the remaining communities were developed by NRPC, current 2002.

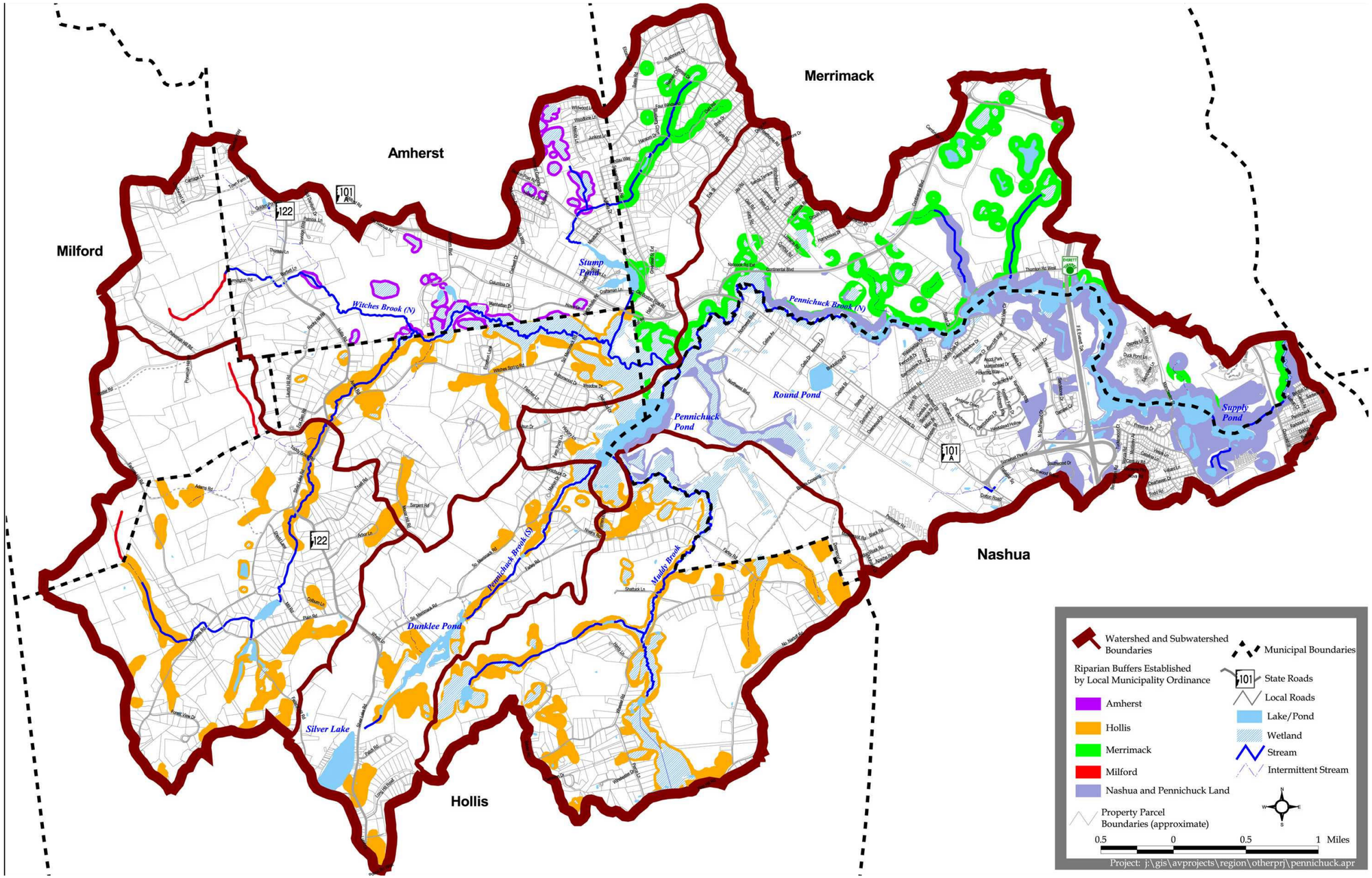
Watershed and Subwatershed Boundaries
Municipal Boundaries
Property Parcel Boundaries (approximate)
Conservation Land
Lake/Pond
Wetland
Stream
Intermittent Stream
State Roads
Local Roads

N
W
E
S

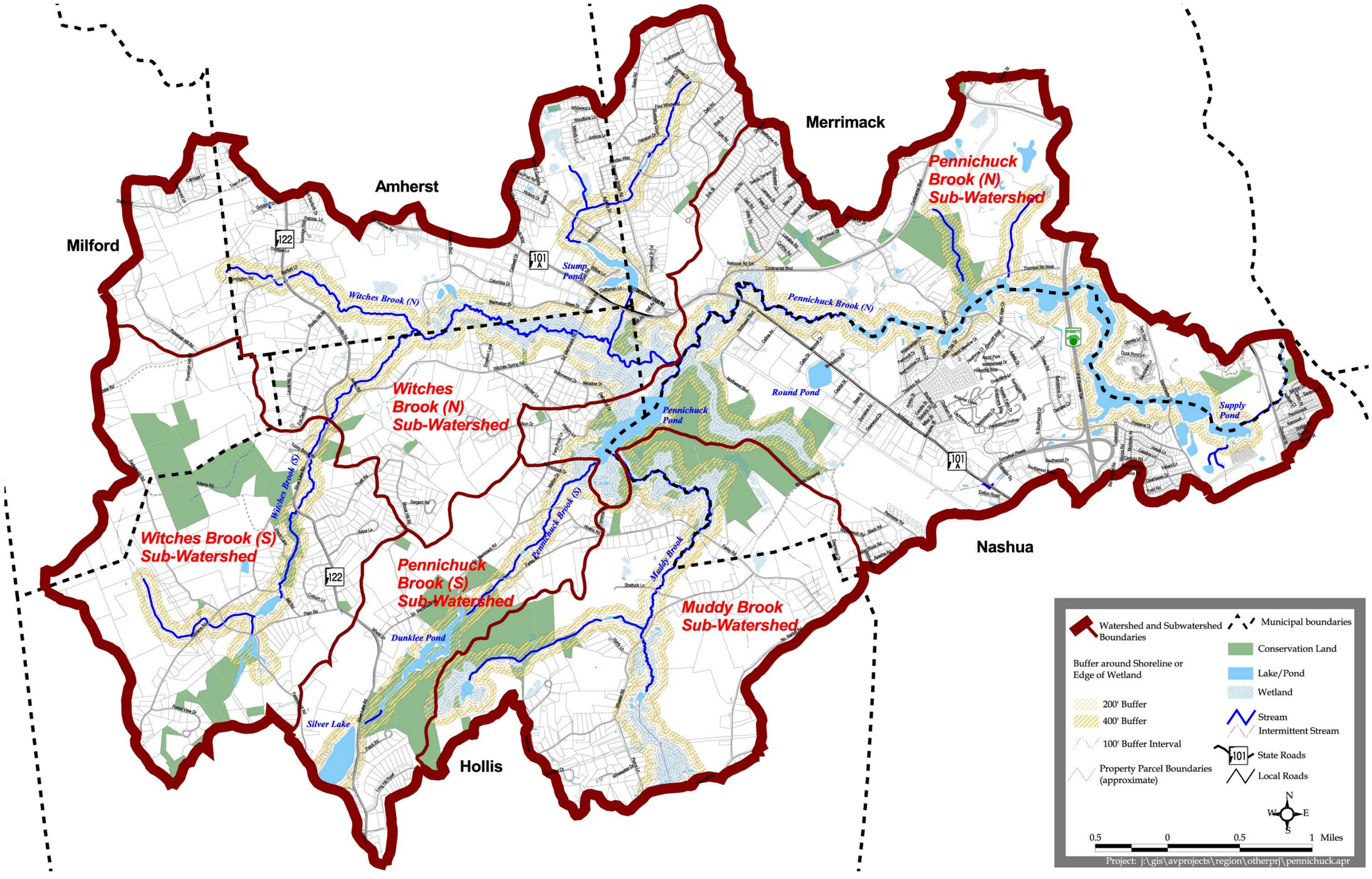
0.5 0 0.5 1 Miles

Project: j:\gis\avprojects\region\otherprj\pennichuck.apr

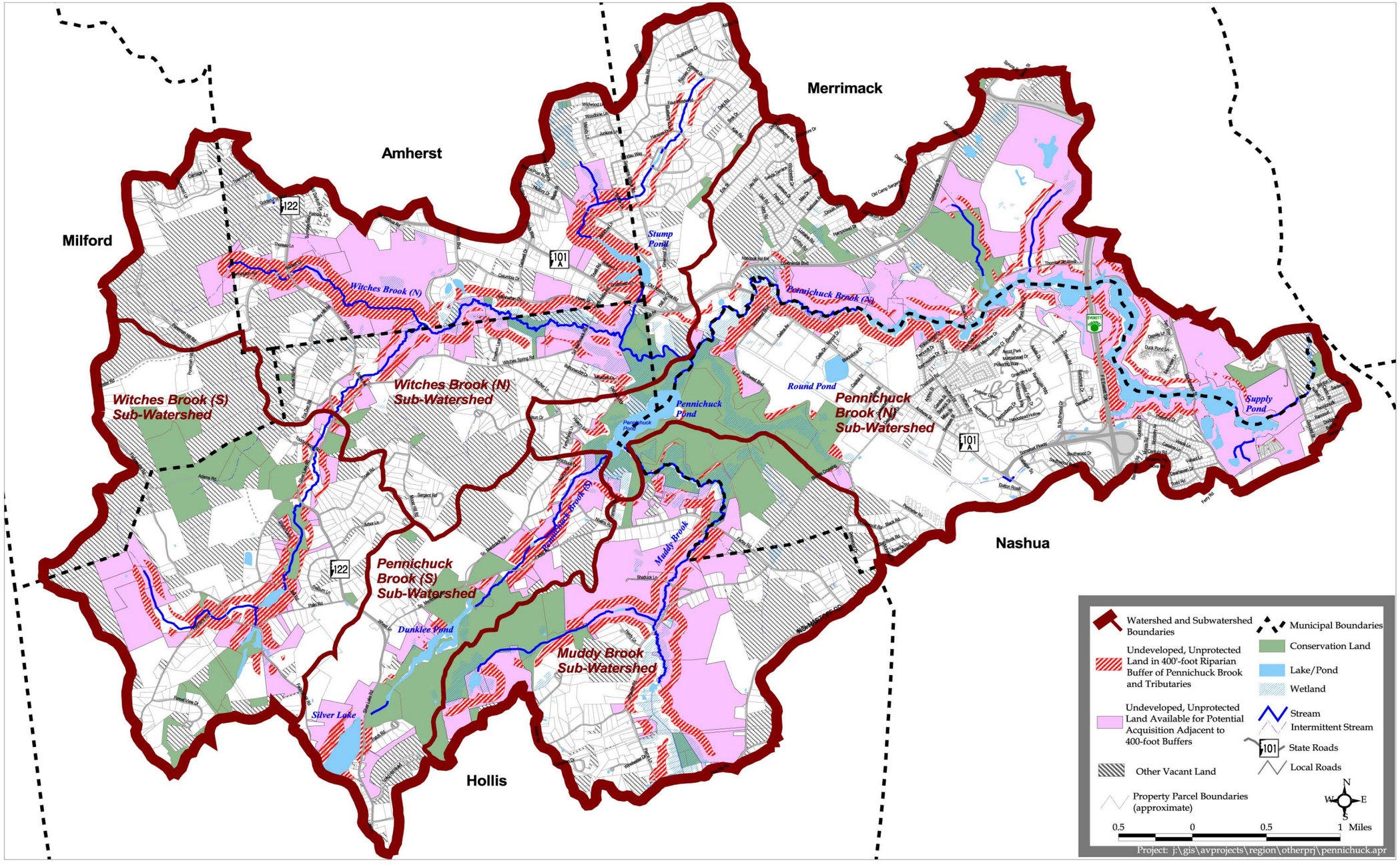
Map 2: Existing Riparian Buffers



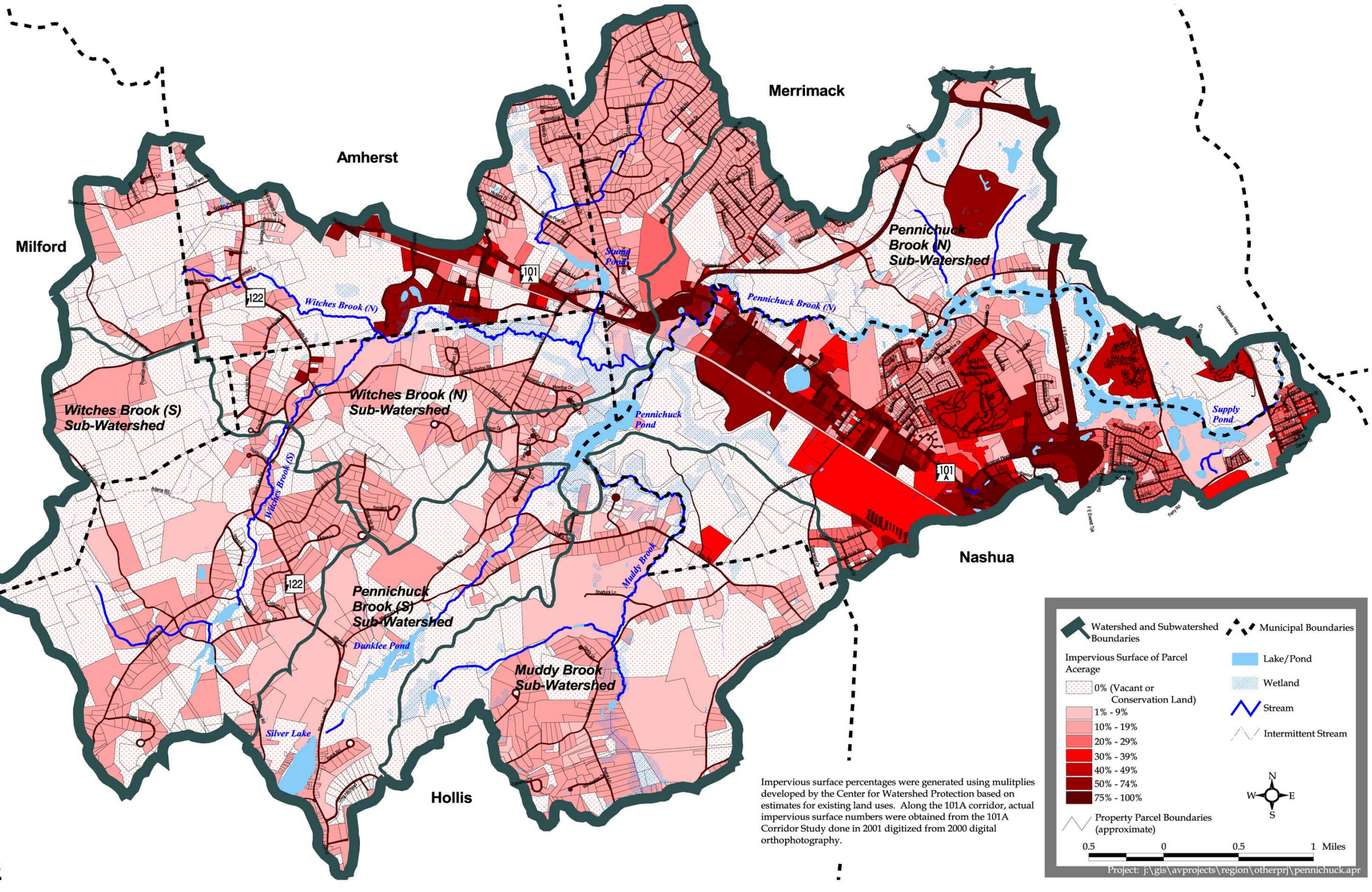
Map 3: Suggested 400-Foot Riparian Buffer



Map 4: Unprotected, Undeveloped Land Adjacent to the Proposed 400-foot Riparian Buffer

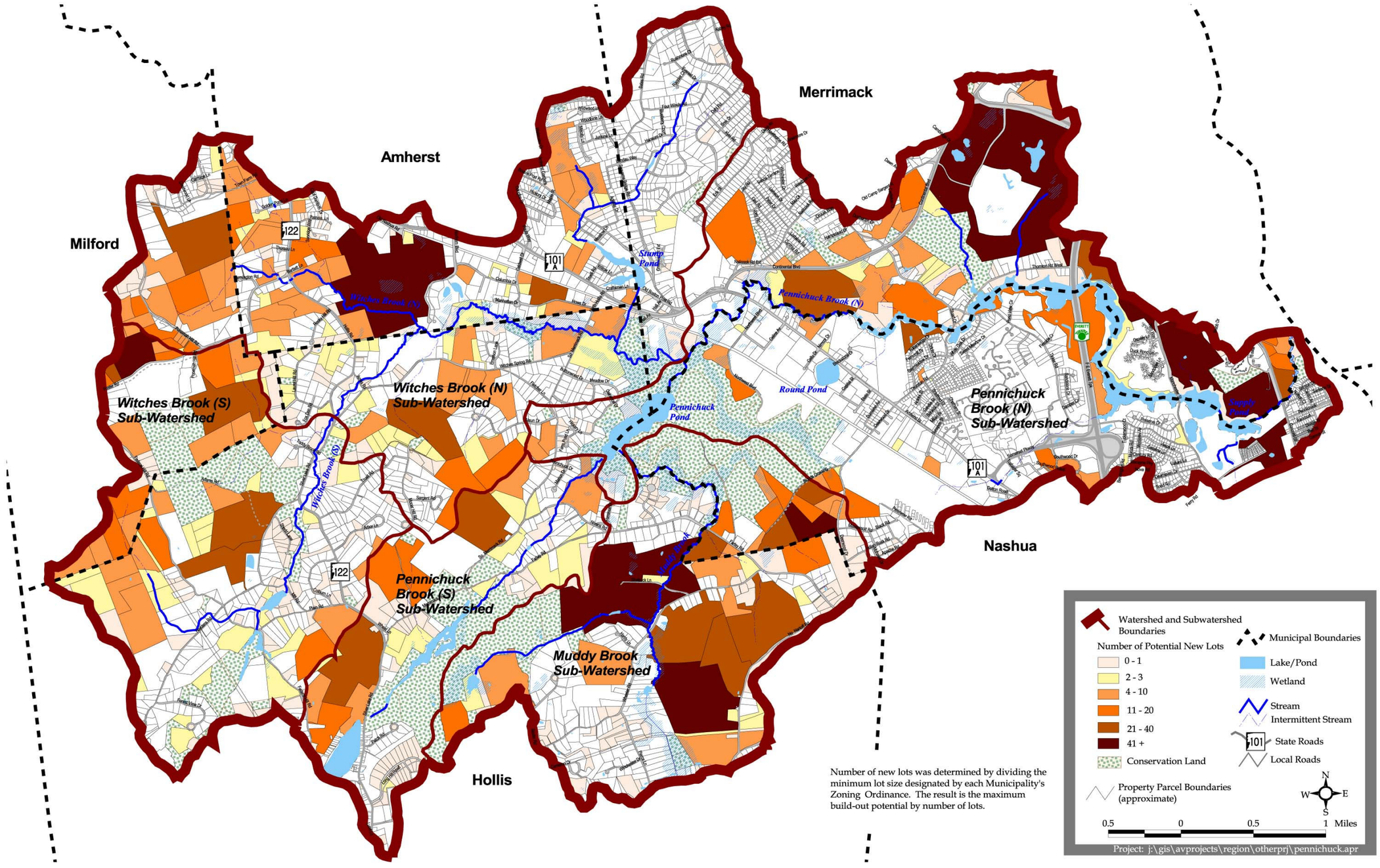


Map 5: Impervious Surface Calculations by Municipality and Subwatershed



Impervious surface percentages were generated using mulitplies developed by the Center for Watershed Protection based on estimates for existing land uses. Along the 101A corridor, actual impervious surface numbers were obtained from the 101A Corridor Study done in 2001 digitized from 2000 digital orthophotography.

Map 6: Build-out Potential by Municipality and Subwatershed



Number of new lots was determined by dividing the minimum lot size designated by each Municipality's Zoning Ordinance. The result is the maximum build-out potential by number of lots.